Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

ANIMAL COVERINGS: FROM THE STANDPOINT OF THE TEXTILE WORKER

ROBERT W. HEGNER
Zoölogical Department, University of Chicago

The material in the following paper was originally prepared for the college class in textiles at the School of Education. It was considered of sufficient value to place before other teachers, not only as an aid in textile work, but also as a means of increasing the points of contact between the child and the lower animals, thus fostering a natural love and sympathy for the creatures that live out of doors.

Before we can consider in logical order the various facts of animal coverings, we must have some knowledge of how the animal kingdom has been divided into groups, classes, etc. Zoölogists recognize a number of groups, or phyla, of animals, which they have arranged, according to their complexity and supposed relationships, into a series beginning with the one-celled forms and ending with the genus *homo*. At one point in their classification, a new character, the backbone, appears, which is so important that the whole kingdom is often divided primarily into two large assemblages, namely, those with backbones, and those without backbones. A simplified form of the classification employed by prominent scientists is given below:

GROUP A. *INVERTEBRATA (ALL ANIMALS WITHOUT BACKBONES)*

Phylum 1. *Protozoa* (one-celled animals, mostly microscopic).
Phylum 2. *Porifera* (sponges).
Phylum 3. *Coelenterata* (jellyfish, coral, etc.).
Phylum 4. *Platyhelminthes* (tapeworms, etc.).
Phylum 5. *Echinodermata* (starfish, sea urchin, etc.).
Phylum 6. *Annelida* (earthworm, leech, etc.).
Phylum 7. *Mollusca* (clam, snail, cuttlefish, etc.).
Phylum 8. *Arthropoda* (crayfish, insects, spider, etc.).

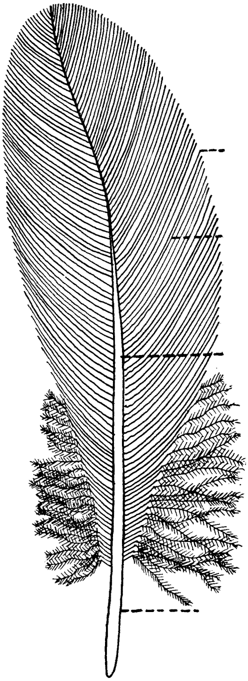

FIG. 1

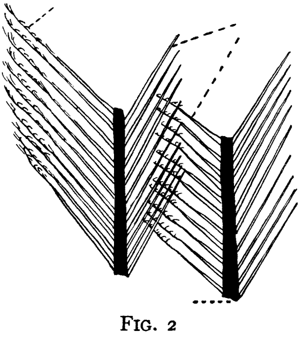

FIG. 2

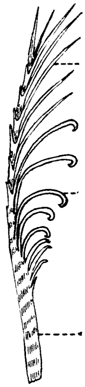

FIG. 3

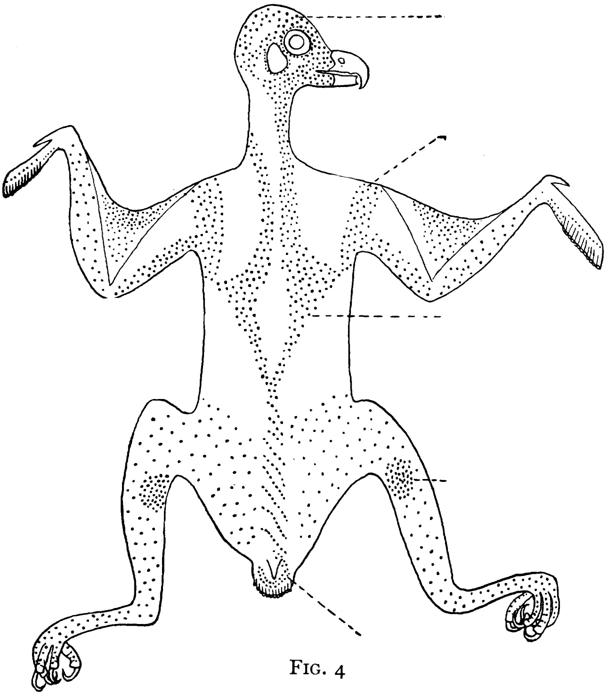

FIG. 4

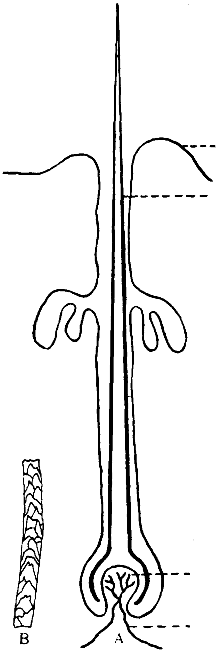

FIG. 5

GROUP B. *VERTEBRATA (ANIMALS WITH BACKBONES)*

Phylum 9. *Vertebrata.*

It is necessary for our purpose to divide the last phylum into its five classes, giving the characteristics that separate each class from the others.

PHYLUM *VERTEBRATA*

Class 1. *Pisces.* (Animals with backbones that spend the whole of their lives in the water. They are usually covered with scales, possess fins instead of jointed limbs and fingers, and breathe by means of gills.)

Class. 2. *Amphibia.* (Vertebrates that spend part of their lives in the water and part on land. They are usually without scales, and breathe by means of lungs.)

Class 3. *Reptilia.* (Vertebrates, usually covered with scales, that breathe by means of lungs.)

Class 4. *Aves.* (Vertebrates with a covering of feathers.)

Class 5. *Mammals.* (Vertebrates possessing mammary glands from which they feed their newly born young. They always have hair on their bodies.)

A fact of interest to us is that these five classes just outlined are distinguished from one another by the *nature of their coverings.* Thus no animal except a mammal has hairs on its body; only birds have feathers; only reptiles have scales and also lungs; only amphibians have naked skins; and only fishes have scales and also gills. This, of course, is only a superficial examination, and there are rare exceptions in each of the above groups. The natural classification depends on the skeleton and other structures that are of more importance, and do not vary as greatly as does the external covering.

The coverings of animals serve various purposes. (1) They prevent serious injury from ordinary accidents, (2) they keep the natural warmth of the body from escaping, and (3) by their colors they protect the animal from its enemies.

The first benefit derived from the coverings need take up little of our space, for it is perfectly obvious how valuable hair, feathers, scales, and shells are to their owners as a protection from injury. We may, however, draw a comparison between these coverings and our own clothing, which gives us a similar immunity from accidents. Shoes, hats, gloves, the headgear of football players and many other articles of apparel are donned expressly to escape injury. In southern warm climates the shoes are reduced to sandals, and hats to sunshades, and in the daytime all clothing becomes a refuge from the burning rays of the tropical sun, while at night it serves to shield the body from the dew and chilly winds.

In considering the second benefit, that of warmth, we must exclude all cold-blooded animals. All invertebrates, fishes, amphibians, and reptiles, are cold-blooded; that is, the temperature of their bodies is generally only several degrees higher than their surroundings. Only birds and mammals then come under discussion here. Birds have a temperature up to 112°F. This is higher than that of man, which is normally 98.3-5°F. It is evident that these animals must have some means of keeping this warmth in their bodies, and this is accomplished by their coverings.

The feathers of birds are remarkable structures, and no organs like them are possessed by other animals. The structure of feathers is very interesting. An ordinary one (Fig. 1) has for its central support a main *stem,* on each side of which is a *vane.* The part of the main stem free from the vane is called the *quill;* the remainder is called the *shaft.* The vane is composed of a number of *barbs* (Fig. 2). Each barb bears smaller structures called *barbules* (Fig. 3) on either side causing it, when viewed under a microscope, to resemble an entire feather. These barbules in turn, in many cases, notably the large wing and tail feathers, carry on their anterior surface—that is the surface toward the tip of the feather—small *hooklets* (Fig. 3). This complete structure is remarkably well adapted for an aërial life. The barbules of one barb overlie those of the preceding barb, forming a diagonal mesh-work (Fig. 2). Each hooklet of one barbule catches in the barbule from the next barb in front, thus further increasing the interlocking. The result is an extremely strong and resistant, though pliant, mechanism—just such as is necessary for the use of the bird in flying.

In the majority of birds there are two kind of feathers. The large ones with vanes are called *contour feathers,* and the small fluffy ones are the *down feathers.* Both kinds lie in sacs in the outer layer of the skin, the *epidermis.*

Just at the base of the rudimentary tail, or "pope's nose," is a gland that secretes an oil. When the bird presses a drop of oil with its beak and dresses its feathers, it is said to be pruning. It is very difficult to wet a bird's feathers, and, as everyone knows, the aquatic birds—ducks, gulls, etc.—can remain in the water indefinitely without any disasters. The oil aids the feather in shedding water, just as a raincoat does for us, and when a bird "prunes" it is simply putting on its waterproofs.

Feathers do not occur over the entire body of a bird, but are restricted to certain tracts caled *pterylae.* The illustration (Fig. 4) shows the feather tracts on the back of a great horned owl.

All birds change their feathers frequently. The young, when newly hatched, are either naked or covered with down. They soon outgrow this, just as young children outgrow their clothes, and in the course of a week or two true feathers begin to appear, and all that remains of the down are a few spots where the baby clothes still show through the contour feathers. The first plumage is worn only a short time; then it gives way to a second plumage. The loss of one set of clothing and the acquirement of another is called "molting." In adult birds molting is annual or semi-annual. All birds shed their feathers in the autumn, after they have finished their household duties for the season, and put on their heavy woolen winter clothing in the shape of a beautiful new set of plumage. In the spring there are many birds that do not consider their ordinary clothes good enough in which to do their wooing; so they change again, and at this time acquire the gorgeous ornaments that are everywhere noticeable just before the breeding season, such as the elegant plumes of the snowy heron, known as "aigrettes."

A much-disputed theory which attempts to account for the beauty of the feathers of male birds at the breeding season is that called "sexual selection." The females are supposed to be attracted by the most brightly colored males, and select them for their mates, the result being that more beautiful males have been bred generation after generation, until by sexual selection the present strikingly ornamental effects have been produced; for example, the birds of paradise, lyre birds, humming birds, etc.

The characteristic covering of mammals is hair. This is undoubtedly extremely well fitted to keep the possessor dry and warm; for humans are ever ready to take the beautiful fur away from them to make coats, boas, muffs, etc., for themselves. Hairs are much simpler in their structure than feathers. They arise from sacs in the epidermis (Fig. 5). Each hair has at its base a papilla, which contains nerves and blood-vessels, and from which a new hair grows if the old one is destroyed. At the sides of the sac are sebaceous glands, which serve to oil the hair and keep it pliable.

Fur is generally composed of one kind of hair; but some animals possess two kinds: (1) long, coarse structures scattered over the body, but not so numerous as (2) the finer underfur. The fur seals are thus covered. Many modifications are found in hairs on different parts of mammal bodies. The long hairs on the tails of horses, the eyelashes of man, the sensitive hairs on the snout of the cat, the spines of hedgehogs and porcupines, are all modifications.

The most useful and most important of all hairs is that found on the sheep, called wool. The fiber of wool is more or less waved. It is a "peculiar modification of hair characterized by fine transverse or oblique lines from 2,000 to 4,000 in the extent of an inch, indicative of a minutely imbricated surface" (Prof. fessor Owen; Fig. 55). These serratures interlock firmly when the hairs are twisted together, and give to wool its felting quality.

In most mammals there is a periodic shedding and renewal of the hair, the new hair arising from the old papilla. This usually occurs in the spring. Low temperatures seem to stimulate the growth of hair, as we find the coats of horses becoming thick and woolly in autumn, and the wool of arctic animals is heavier than that of like creatures found in warm climates.

There is a seasonal change in the colors of certain mammals. The polar hare and the arctic fox show this to a remarkable degree. In them the hair becomes pure white in the winter. This, of course, makes them inconspicuous against a background of snow, and helps them escape the sharp eyes of enemies. "In the case of Ross's lemming, we know that this change is due to the influence of the cold, and depends in great part on the appearance of gas bubbles inside the hairs" (Thomson).

The value of color in nature, our third topic, cannot be overestimated. Large volumes have been written regarding the various benefits derived from advantageous colors, and indeed the very lives of most animals depend on their power to conceal themselves amid their surroundings so effectually as to escape their enemies. Obviously only the principal and most easily explained phenomena can be considered in this paper.

Color is caused by white light being broken up into its various wave-lengths. When an object appears black, it is because it has absorbed the entire complex of white light. When an object appears red, it has absorbed all the elements of white light except the red wave-lengths, which are reflected and make an impression on our eyes. Colors have been divided into (1) structural and (2) pigmental. The former occur to perfection in the gorgeous raiment of birds and butterflies. The changeable colors seen on humming-birds, on the neck of the pigeon, and on numerous other birds are optical effects due to modifications of the feather structure. The exact physical causation of the colors is unknown. Pigmental colors are due to the presence in the organism of substances of definite chemical composition that react to light always in the same way. The green color in plants is a good example. It is due to a pigment called chlorophyll that acts when extracted from the plant body exactly as when within the tissues.

Poulton, in his book on *The Colors of Animals,* gives in concise form the uses of color, and later gives a full explanation with examples under each.

I. NON-SIGNIFICANT COLORS.—These are colors that are due to chemical or physical structure, valuable to the animal not because of their color itself, but because the organs that contain it are of value. For example, blood is red and fat is white.

II. SIGNIFICANT COLORS.

1. *Colors of direct physiological value.*—Included under this head are those colors that are of importance in retaining and giving off heat. Dark colors readily absorb radiant heat, and light colors do not. For this reason black clothes are the warmest in hot weather and white most comfortable. This may account for the change of colors at different seasons of the year. However, a dark surface readily parts with heat, while a white surface tends to retain heat, and this may be a factor in the coloration of animals. For example, the white appearance of arctic birds and mammals must be advantageous for concealment in a region so largely covered with snow, but it is very probable that advantage is also secured by checking the loss of heat through radiation.

2. *Protective and aggressive resemblance.*—An animal is *protectively colored* when it resembles its natural surroundings in such a way as to elude its enemies. Almost all animals are thus protected, familiar examples being the insect known as the walking stick, which so closely resembles a twig as to be practically invisible among the branches of trees; and the owlet-moths belonging to the genus *Catocala,* which are safe from discovery while resting on the bark of trees. *Aggressive coloration* is possessed by animals that resemble their surroundings so closely that they can steal upon their prey unseen. This style of coloration is found in many snakes, lizards, etc., whose skins harmonize with their habitat and enable them to get close to their victims.

3. *Protective and aggressive mimicry.*—In this case the animal gains advantage by superficial resemblance to some other form. *Protective mimicry* occurs when one animal resembles another which is immune from attack from other animals because of its sting, offensive taste, or smell. An animal shows *aggressive mimicry* when it resembles another so that it can injure the latter or some other form which accompanies it or is not afraid of it. A well-known case of protective mimicry occurs in two species of butterflies belonging to the group of which the common monarch or milkweed butterfly is an example. *Danais erippus* is immune because of its offensive taste, and is mimicked by *Limenitis aichippus.* These both live in Central America.

4. *Warning colors.*—Bright colors are of advantage to animals that possess unpleasant qualities, such as taste and odor, as other forms can easily recognize one so colored and "pass by on the other side." This is a rather common condition among the butterflies. The above example, *Danais erippus,* serves here also, as its bright colors advertise it from afar and lessen the danger of a bird mistaking it for another species.

5. *Colors displayed in courtship.*—These are colors that appear only during the breeding season and are of common occurrence among the birds. The presence of brilliant plumage is accounted for by sexual selection, as has been explained in the discussion of feathers.

The insects are the most diverse and highly colored of animals, and examples of all the above styles may be found easily among the members of that class. They are more frequently used by authors than other forms to illustrate the various color classifications and theories. Among the vertebrates, birds undoubtedly hold first place, and one has but to examine a book on ornithology that contains colored plates to realize that the feathered animals carry all the colors of the rainbow on their backs. Bright colors in mammals are comparatively rare, their coats being usually uniform, with stripes and spots by way of variety.

A few animals are especially interesting with respect to their coverings, and I wish to discuss these separately.

1. *Whales* were for hundreds of years thought to be fishes. Their structure, when they were examined by morphologists, proved them to be mammals. They are covered with a heavy skin, and the hairs are reduced to a few isolated specimens in the neighborhood of the muzzle. The presence of blubber just under the skin no doubt accounts for the absence of hair, as it prevents the dispersal of the body heat.

2. *Elephants* are restricted in their habitat to Africa and Asia, although they once inhabited America. There are only two species now living: (1) *Elephas indicus,* with small ears, and (2) *Elephas africanus,* with large ears. Other forms have become extinct. The elephant of today has very few hairs on its body, but it has a very thick skin, which protects it from injury

and keeps in all the warmth that is necessary considering the temperature of its present home. The elephants of former times were very differently clothed. They lived in colder climates and needed more protection than that afforded by their skins. Specimens found frozen in ice in Siberia have close woolly hair, in some places three feet long.

3. *Armadillos* are small animals confined entirely to South America except one that comes as far north as Texas. They are unique among living mammals in having an armature of bony plates united into shields and rings, and covered by horny epidermis. This is just such a coat of mail as the knights of olden times used to wear when they sallied forth to do battle. The armadillo, despite these bony plates, still comes under our definition of a mammal, because here and there hairs are found protruding from the joints of the shields.

4. *Rhinoceros.*—Species of this animal occur in Africa and parts of India. The skin is very thick, with scanty hair. Similar arguments may be used here to account for the decrease of fur as were suggested with the elephants.

5. *Snowy owls, snow-buntings, ptarmigans,* and numerous other northern birds become white in winter, for no other reason apparently than that they may be better protected from enemies. Natural-selectionists account for the change by claiming that those birds with this advantageous tendency of bleaching survive and transmit this characteristic to their progeny until the tendency results in a fully developed seasonal change.

6. *White mice, white rats,* and other animals with white fur or feathers are called "albinos." There is no coloring matter in their hair or feathers. These animals cannot exist under natural conditions, because they are conspicuous both day and night. The opposite condition is called 'melanism." This is the result of an excess of pigment in the hair or feathers. Black wolves and rabbits are melanic forms.

7. *Chimney swifts and woodpeckers* make special use of their tail feathers to brace themselves when clinging to sides of trees or chimneys. The vanes have disappeared from the end of the tail feathers of the swift, leaving a strong sharp spine.

Grouse that stay with us all winter have slender toes in the summer, but in the autumn, when snow comes, they acquire a comblike fringe on either side, which they wear instead of snowshoes until the following spring.

The tails of birds that are continually on the wing have become adapted to their mode of locomotion, and act as rudders in flight and balancers when perching.

LITERATURE

Every textbook of zoölogy will give more or less in detail information on the subjects treated in this paper; but no one book gives all. Thomson's *Outlines of Zoölogy* is the simplest and most comprehensive of the host of zoölogical textbooks. Besides a review in order of the groups of animals with a detailed study of a type under each, there are chapters on comparative physiology, geographical distribution, and the theories of evolution. Parker and Haswell's textbook is larger, and is valuable for reference. The volumes of the *Riverside Natural History* and the *Cambridge Natural History* pay more attention to the habits of the various animals and less to their anatomy. These are of great value to textile workers. All the books mentioned are well known, and are to be found in every good scientific library.

1. Thomson, J. Arthur. *Outlines of Zoölogy.* New York: D. Appleton & Co., 1899. Third edition, 819 pages, 322 illustrations. $3.50.
2. Parker, J. F., and Haswell, W. A. *Text-Book of Zoölogy.* New York: The Macmillan Co., 1897. Two volumes. Vol. I, Invertebrates; Vol. II, Chordates. $9.
3. *Cambridge Natural History.* New York: The Macmillan Co. Ten volumes by special authors.
4. *Riverside Natural History.* New York: Houghton, Mifflin & Co. Six volumes by special authors.

There is an infinite amount of literature relating exclusively to birds. Perhaps the best of these for our purposes is that by Beddard on the *Structure and Classification of Birds.* Frank M. Chapman's *Bird Life* contains a very clear account of avian peculiarities in the first eight chapters, pp. 1–83. Newton's *Dictionary of Birds,* Cone's *Key to North American Birds,* Part II on "General Ornithology," pp. 59–244, and Headley's *Structure* *and Life of Birds* treat very fully such questions as the structure of feathers, molting, seasonal changes in color, migration, etc.

1. Beddard, Frank E. *The Structure and Classifications of Birds.* New York: Longmans, Green & Co., 1898. 548 pages.
2. Newton, Alfred. *A Dictionary of Birds.* London: Adam & Charles Black, 1896. 1088 pages.
3. Chapman, Frank M. *Bird Life.* New York: D. Appleton & Co., 1901. 270 pages, 75 colored plates, appendix for teachers. $2.
4. Cones, Elliott. *Key to North American Birds.* Boston: Dana, Estes & Co., 1903. Two volumes. 11552 pages.
5. Headley, F. W. *The Structure and Life of Birds.* New York: The Macmillan Co., 1895. 412 pages.

There are three books that give the general facts and theories of color in nature. Many other references might be given, but these are the ones most easily obtained, and give as full an account of the subject as is necessary for textile workers:

1. Poulton, Edward B. *The Colours of Animals.* New York: D. Appleton & Co., 1890. 360 pages, 66 figures. $1.25.
2. Beddard, F. E. *Animal Coloration.* New York: The Macmillan Co., 1895. 288 pages, 36 illustrations, 4 colored plates. Second edition.
3. Newbigin, Marion. I. *Colour in Nature.* London: John Murray, 1898. 344 pages.